Cold Regions Research and Engineering Laboratory

ERDC/CRREL TR-12-5

US Army Corps of Engineers®
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Preliminary Permafrost and Hangar Investigation

Naval Arctic Research Lab, Barrow, Alaska

Kevin Bjella

July 2012

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Final report

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Prepared for U.S. Navy

Abstract: Supporting a U.S. Navy initiative to provide expedient logistical operations for the U.S. Arctic coastal region, the Army's Cold Regions Research and Engineering Laboratory (CRREL), accompanied CDR Eric Buch, USN, on 12 July 2011, for a fact finding trip to Barrow, Alaska. One purpose of this trip was to determine if legacy Navy infrastructure at the old Navy Arctic Research Lab (NARL) could be used to any degree for this initiative. The report is a briefing of the findings, including recommendations for follow-on work, if warranted.

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Preface

This study was conducted for the U.S. Navy; CMD Eric Buch USN.

This report and field work was completed by Kevin Bjella (Force Projection and Sustainment Branch, Dr. Edel Cortez, Chief), U.S. Army Engineer Research and Development Center/Cold Regions Research and Engineering Laboratory (ERDC/CRREL). At the time of publication, Dr. Justin Berman was Chief of the Research and Engineering Division. The Deputy Director of ERDC-CRREL was Dr. Lance Hansen and the Director was Dr. Robert Davis.

The author gratefully acknowledges the assistance of Dr. Edel Cortez (CRREL) for his review of this report. The author also thanks Greenland Contractors personnel for their support during the field work; CDR Eric Buch, USN, for allowing this opportunity to examine permafrost-affected, legacy DoD infrastructure; and Kevin Knuuti, CRREL Technical Director's Office, for support of this trip. For more information contact:

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COL Kevin J. Wilson was the Commander and Executive Director of ERDC, and Dr. Jeffery P. Holland was the Director.

Unit Conversion Factors

Multiply	By	To Obtain
degrees Fahrenheit	(F-32)/1.8	degrees Celsius
feet	0.3048	meters
inches	0.0254	meters
miles (U.S. statute)	1,609.347	meters

1 Background

It is our understanding that the U.S. Navy possibly will acquire the Finnish air cushion vehicle (ACV), Tuuli. This project aims to provide a level of U.S. logistical capability that does not currently exist for the coastal regions of northern and western Alaska. To demonstrate the feasibility of the vehicle, a 2-year, proof-of-concept trial would be undertaken, requiring infrastructure to house the vehicle for storage and maintenance. Two hangars exist at Barrow, Alaska, located at the NARL site a few miles outside of the village. These hangars may have the ability to house the ACV and additional support equipment. CDR Buch requested CRREL to observe and provide expertise regarding any past or possible future effects due to permafrost that underlies the buildings. It should be noted that this investigation was conducted without the benefit of a subsurface investigation.

This report describes preliminary impressions found only on visual observation. No soil borings or geophysical investigations were conducted, and no engineering analysis was completed. The findings in this report should not be used to ascertain functional readiness of the structures, but should be used for planning and a starting point for determining functional readiness. To positively and accurately identify the existing conditions and to make definitive long-term plans for the hangars will require invasive testing. For the 2-year proof-of-concept trial, assumptions are being made based on above-ground observations and experience.

We visited the hangars on 12 July 2011 for a full afternoon, and were allowed to investigate all areas. The first hanger visited was the “Navy” hangar (Fig. 1–4), and the second hangar was the “Air Force” hangar (Fig. 1, 5, 6, 7). The Navy hangar is located approximately 1000 ft inland from the beach at the southwestern end of the runway. The Air Force hangar is located approximately 500 ft northeast of the Navy hanger and slightly closer to the runway. The Navy Hangar is approximately 200 × 160 ft (L × W) with office and storage space at the rear, and the Air Force Hangar is approximately 130 × 130 ft with no office or storage space. Because of the sandy nature of the surface soils, interlocking steel aircraft matting was laid on the entire runway surface, the entire surface of the ramps and aprons leading to the hangars, and entirely within the hangars for floor-

ing. The areas behind each hangar consist of small lakes surrounded by native vegetation.

Figure 1. April 2009 aerial view of hangar layout (scale 1 in. = 800 ft, north at top).

Figure 2. Front wall of the Navy hangar (level and plumb lines throughout).

Figure 3. Back wall of the Navy hangar with office and storage. Note the gravel fill thickness of 4 to 5 ft above the native soils.

Figure 4. Navy hangar. This is the roof truss column where it rests on the pile cap. Note the concrete stem wall in the background. No cracking or separation was found at these junctions.

Figure 5. Front view of the Air Force hangar (level and plumb lines).

Figure 6. Pile cap exposed along the outside wall of the Air Force hangar.

Figure 7. Interior view of the Air Force hangar.

2 Preliminary Information

For the sake of this discussion, the soils of the Barrow area, including the NARL site between the village and Elson Lagoon to the northeast (Point Barrow), can be generalized into two types. Along the beach soils appear to be fine and coarse sands with some silt and small gravel (Brown 2003), and this appears to exist to some distance inland, at least 150 to 200 ft. Information was not found on the limits of permafrost in these beach sediments, but it is likely it exists to within proximity (tens of feet) of the sea, if not up to and under the sea. It is possible that massive ice (ice wedges and segregated ice) could exist in these soils, and it is certain matrix ice exists. It was difficult to find any undisturbed beach sediments to examine as this coastal margin has become the location for a road, runway, and is often trafficked by associated shoreline work needed to redistribute the beach sands after storms and ice shove events.

Moving inland, one finds the soils to be more silty and organic rich, with tundra vegetation and numerous wind-elongated lakes at the surface. Polygonal ground is very evident between the lakes, indicating massive ice-rich soil with ice wedge networks. The polygons are tens of feet in diameter, and the ice wedges are likely feet in width and up to 10 ft deep. Segregated ice (ice lenses) more than likely exists at various depths (Brown 2003), and is probably inches in thickness and feet in lateral extent. The farther inland structures at NARL have suffered settlement from thawing permafrost, and, therefore, most of the station was located closer to the beach. It is not known how the soils transition from the beach sediments, to the finer grained organic sediments inland. Owing to the distance from the beach and the proximity of the polygonal ground behind the hangars, it is assumed these hangars were constructed over ice-rich permafrost, and this should be definitely investigated as part of a final engineering assessment.

Foundations of occupied structures at Barrow consist of mostly elevated single and multi-family dwellings on piles, or post and pad type foundations. Larger structures are elevated on piles, or have refrigerated soils via thermosyhpons, with at grade foundations. A small (20- × 30-ft) soil remediation structure adjacent to the Navy Hangar and built in the early

1990's has refrigerated soils via thermosyphon under the monolithic concrete floor.

No information was readily found describing the design of the hangars; however, personnel from the early days of NARL are still located in Alaska. A telephone call was placed to John Schindler, Assistant Director of NARL in the 1950s and 1960s, and who worked with the Director Max Brewer. John is very familiar with these buildings and provided the following:

- The Air Force Hangar was the first to be constructed, in the late1940s when NARL was first constructed. The Navy Hangar was constructed in the 1960s.
- The hangars are constructed on approximately 4 ft of structural fill (screened gravel), over ice-rich permafrost. It is unknown if the vegetation was removed prior to placement (Fig. 3).
- The load bearing end walls of both hangars rest on monolithic concrete stem walls. This wall rests on concrete pile caps, which then rest on piling installed to at least 10 ft deep (Fig. 4, 8).

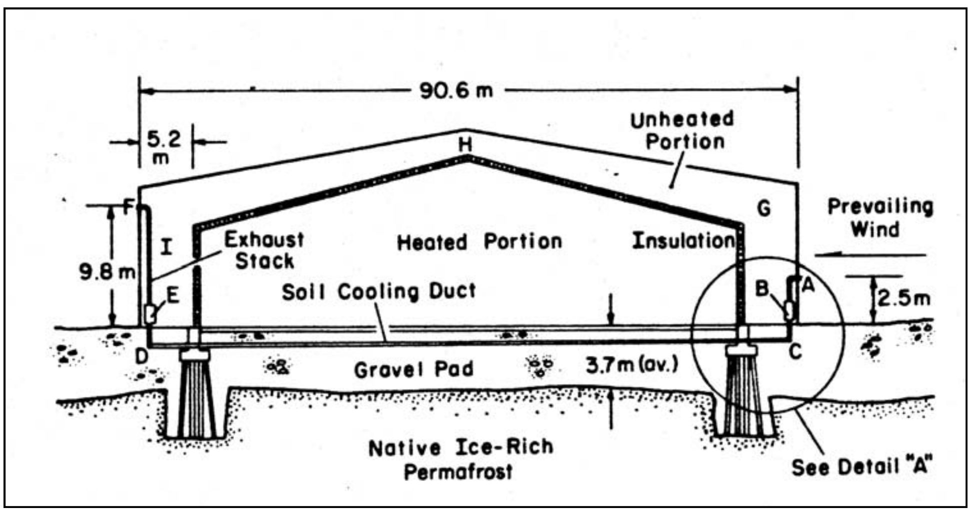

Figure 8. Elevation view of hangars at Thule Air Force Base. The Navy and Air Force hangar at NARL are similarly constructed with pile and pile cap systems.

- The floor in the Navy hanger has been filled with gravel many times (?) because of thaw settlement of the ice-rich soils below. John estimated over 6 ft of total settlement. The mats would be lifted, gravel placed, and the mats replaced. It is unknown if this was done in the Air Force hangar.

- Despite the extreme settlement within the footprint of the Navy hangar, there was never any indication that thaw settlement was affecting the load bearing elements.
- The hangars were heated for the entire time that Mr. Schindler worked at the station. It not known when the hangars were last used specifically.

3 Findings

The interior floor of the Navy hangar was in disarray from soil remediation work that was conducted inside during the 1990s, so there was no visible evidence of floor settlement mentioned earlier. We were told by personnel familiar with the hangar that the main sliding door on the front of the hangar was not operative, but this could be attributable to no electric power remaining to the structure, and not a misaligned track or settlement along the threshold. Visual examination of the monolithic stem wall and pile caps revealed no distress. No cracking of the concrete of the wall or caps was visible (Fig 4). No separation was visible between the steel truss columns and the stem walls, which might indicate movement. All walls and corners appeared plumb, and all eve and ridge lines appeared level. The exterior metal cladding had no visible signs of warping or separation, and the soil fill around the outside of the stem wall was level with no visible signs of settlement. Overall, this hangar gave an appearance of being in suitable condition.

The Air Force hangar was rougher in appearance than the Navy hangar, but upon closer inspection this was mainly because of the deterioration of the outside cladding, which was missing in places, most probably because of wind, and damaged in other areas from equipment impacts. Otherwise, the same observations mentioned above for the Navy hangar apply to this hangar as well. The steel floor matting was intact in this hangar and did exhibit an undulating surface, with a wavelength on the order of tens of feet, and a maximum wave height of 1.0 ft, crest to trough, measured during this investigation.

4 Discussion

The information provided by John Schindler, and the visible pile caps at each hangar, indicate that both hangars may have been constructed in a similar fashion, with perimeter pile systems extending to some depth into the permafrost. A similar type foundation system exists in the hangars at Thule Air Force Base, Greenland (Fig. 8). Although the soils at Thule consist of greater portions of all particle sizes (silt to cobbles), the climate is very similar, with similar permafrost temperatures at 11 to 12°F. In some of the Thule hangars, extreme thaw settlement (5 to 6 ft) had occurred in the floors. However, because the piles systems extended to sufficient depth, and along the perimeter of the structure, the load bearing, frozen soils were not affected by the thaw bulb progression under the floor (Fig. 9). Therefore, there was no thaw settlement causing structural distress in the superstructure (Bjella 2010). It is hypothesized this may be the case with both the hangars at NARL.

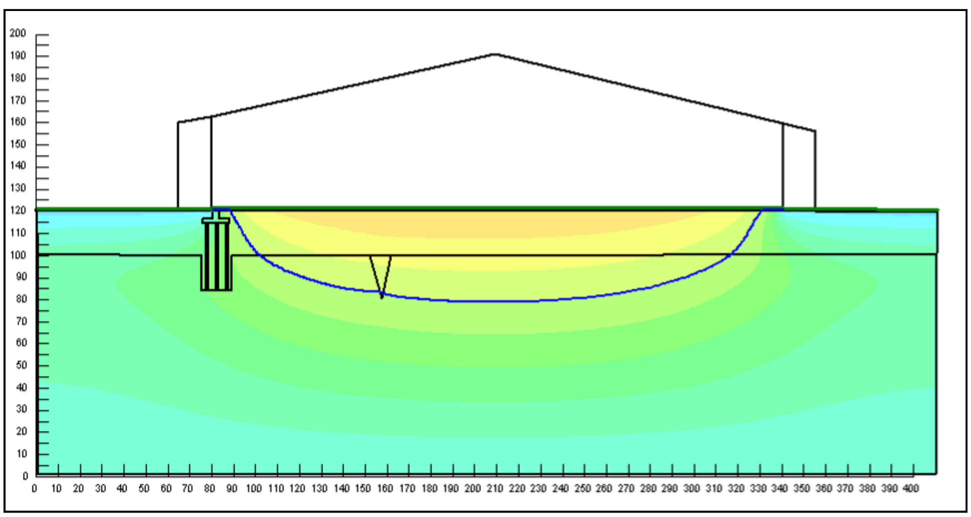

Figure 9. Two-dimensional computer thermal model run for a similarly constructed hangar at Thule Air Force Base. The black horizontal subsurface line is the top of permafrost, and also bottom of structural fill. The blue line is the thaw front from 60°F interior heating after 30 years. For simplicity, only one pile system is shown. Note the thaw front does not impact the base of the piles embedded in the permafrost. This simulation was also run for 50 years with no significant lateral widening of the thaw bulb (Bjella 2010).

Heating system maintenance tags found in the NARL hangars suggested they have not been heated since the early 1990s. No matter what depth the permafrost thawed while they were heated, it most certainly has ag-

graded back to the surface, minus the seasonally thawed layer. Without the benefit of soil borings to confirm the presence of ice, it is difficult to postulate what may occur if the hangars were heated again. Approximately the upper 4 ft of soil consists of placed fill, and more than likely does not contain significant ice even now after refreezing. This may or may not be the case for the upper few feet of the native soil below the fill. Modest heating of the hangars will re-initiate the thaw bulb progression, but may not affect ice-rich soil within the 2-year trial period. Heated shelters having smaller footprints within the hangars would limit the thaw bulb progression in comparison to whole hangar heating. Longer term use with heating would require analysis of the soil column for material type and ice content to understand how thaw bulb progression will affect the floor and structure. It is highly probable that after some time of renewed heating, thaw settlement would again occur in the floor. Details of the building construction and a soil column analysis would be needed to determine if the pile systems would be in jeopardy with long-term renewed heating.

5 Recommendations

The superstructure integrity of the two hangars at NARL, with regard to permafrost stability, appear to be unaffected by the decades of heated use, though this is something that should be determined as part of formal engineering assessment. The floors have been witness to extreme thaw settlement, however, but this is not unexpected and visibly does not appear to have affected the structures. It is recommended that, before further use, CRREL be retained to review the final plan, provide comments and suggestions, and conduct thermal modeling to understand how heating may affect these structures. CRREL owns and operates all the tools necessary to do subsurface permafrost investigations—this includes a subsurface soil drilling rig, ground-penetrating radar, and electrical resistivity equipment. All is readily available at our Ft. Wainwright field office.

References

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Brown, J., and M.T. Jorgensen. 2003. Long term rates of coastal erosion and carbon input, Elson Lagoon, Barrow, Alaska. *Proceedings of the Eighth International Conference on Permafrost.*

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
July 2012

2. REPORT TYPE
Technical Report

3. DATES COVERED *(From - To)*

4. TITLE AND SUBTITLE
Preliminary Permafrost and Hangar Investigation: Naval Arctic Research Lab, Barrow, Alaska

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Kevin Bjella

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Cold Regions Research and Engineering Laboratory
U.S. Army Engineer Research and Development Center
72 Lyme Road
Hanover, NH 03755

8. PERFORMING ORGANIZATION REPORT NUMBER
ERDC/CRREL TR-12-5

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Navy

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

Supporting a U.S. Navy initiative to provide expedient logistical operations for the U.S. Arctic coastal region, the Army's Cold Regions Research and Engineering Laboratory (CRREL), accompanied CDR Eric Buch, USN, on 12 July 2011, for a fact finding trip to Barrow, Alaska. One purpose of this trip was to determine if legacy Navy infrastructure at the old Navy Arctic Research Lab (NARL) could be used to any degree for this initiative. The report is a briefing of the findings, including recommendations for follow-on work, if warranted.

15. SUBJECT TERMS
Air Cushion Vehicle
Arctic construction
Reuse of buildings
Thaw settlement

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER *(include area code)*
U	U	U	U	22	